Improving plastic surgery care of hand trauma using the lean thinking model

Abstract

Plastic surgery trauma care services vary widely between hospitals in the UK. The authors evaluated their plastic surgery trauma service and illustrated the use of lean thinking to successfully implement small interventions to create positive change. The study findings demonstrated an increase in the proportion of patients with trauma being treated in the outpatient clinic rather than in the main theatres. This coincided with an increase in the proportion of patients being treated on the day of presentation to hospital.

Key words: Hand trauma; Lean model; Plastic surgery; Quality improvement

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Ilias E Epanomeritakis[1]

Tze Khiang Tan[2]

Kai Yuen Wong[3]

Author details can be found at the end of this article

Correspondence to:
Ilias E Epanomeritakis;
iee21@cantab.ac.uk

Introduction

Major trauma centres were introduced in the UK in 2012 in response to deficiencies in NHS trauma care compared to other healthcare systems, and to address wide variation in practice across the country (National Audit Office, 2010; Moran et al, 2018). In contrast to previous practice, this centralised model dictates that patients with trauma are brought directly to regional major trauma centres rather than the nearest emergency department. This has resulted in an increase in the proportion of patients with trauma being treated in major trauma centres and the amount of consultant-led care, and a significant reduction in death rates (Moran et al, 2018).

As part of a multidisciplinary team, plastic surgeons play a key role in the management of trauma cases in major trauma centres (Hendrickson et al, 2018). Hand trauma accounts for about 20% of emergency department presentations, and largely affects the working population (Robinson et al, 2016). Hand trauma, therefore, creates significant cost for both the affected individual and wider society. In addition, post-traumatic stress disorder often accompanies severe work-related hand trauma. This has further implications for returning to work, with financial consequences for the individual as well the healthcare service, resulting from the need for psychotherapy (Grunert et al, 1990).

Delays in treatment of hand trauma are common (Athar et al, 2019). The provision of efficient, cost-effective care for patients with hand trauma requires a streamlined referral and treatment pathway which avoids excess waste. Waste may refer to any type of inefficiency in service provision, causing excessive use of resources or time. The lean quality improvement model focuses on identifying and removing 'waste' to improve operational efficiency (Bharsakade et al, 2021). Following its success in the car manufacturing company, Toyota, it has been applied across many enterprises, including healthcare. The fundamental principles of this model concern the performance of the worker, with a focus on providing a framework for workers to develop better technical skills and continuous re-assessment and improvement of the treatment pathway (Teich and Faddoul, 2013). In addition to having positive impacts on quality outcomes, the lean model also serves as a catalyst for changes in the technical and non-technical aspects of healthcare organisations.

Recognising the need for safe and timely care for patients with hand trauma, the authors evaluated their trauma service for possible sources of 'waste' using the lean thinking model, and implemented solutions to streamline the care process.

Methods

All patients who attended a plastic surgery trauma clinic at a single district general hospital in the UK over 6 consecutive months in 2014 were prospectively studied. These included

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both paediatric (<16 years old) and adult patients. A total of 476 patients were included in the study, who were referred to the clinic by GPs or the emergency department. The trauma clinic is a weekday service, operating from 09:00–17:00. The unit comprised six plastic surgery consultants, two plastic surgery registrars, two core surgical trainees, two plastic surgery nurses and four hand therapists whose role was to enable patients' return to daily activities following their injury. Patient demographics, injury modality, diagnosis, treatment timings and delays were analysed. Inpatient referrals were excluded, as they followed a different referral pathway and were not assessed in the trauma clinic.

'Waste' was initially identified in an information-gathering phase conducted by the authors. A multidisciplinary team composed of plastic surgeons, trainees and plastic surgery nurses designed and implemented the intervention, which was followed by three 2-month cycles of baseline measurement and post-intervention assessment.

The 6-month period was divided into three 2-month quality improvement cycles. After the first 2-month cycle, which represented baseline activity before any intervention, capacity was increased by setting up a local anaesthetic operating list alongside the trauma clinic which would be primarily led by surgical trainees. This was facilitated by adequately stocking the trauma clinic with necessary equipment and ensuring supervision of trainees by consultant surgeons. The following two cycles reviewed progress to ensure consistent adoption of the new practice across the clinic. Table 1 details the types of waste as outlined by the lean model and how these were addressed in the current study with the implementation of the clinic operating list.

Statistical analyses were performed using the RStudio application. One-way analysis of variance (ANOVA) tests for unpaired parametric data were used to analyse differences in the mean time taken to reach certain points in the treatment pathway across the three cycles. The Chi-squared test was used to assess for significant differences in the locations of definitive treatment, ie whether this took place in the main theatres or trauma clinic, and the proportion of patients treated on the day of presentation, across the three cycles.

Table 1. Lean model categories of waste in trauma clinic setting

Waste type	Presentation in trauma clinic	Impact of setting up local anaesthetic operating list
Defects	Incidence of procedural mistakes or complications	More timely service delivery with no increased rate of complications
Waiting	Patients waiting for a specialist assessment, a surgery date more than 24 hours after presenting to hospital or waiting for several hours on the day of surgery for the procedure	Same day treatment in trauma clinic, bypassing the need for an operating theatre slot
Transport	Lack of equipment in trauma clinic, resulting in cases of minor injuries and repairs being treated inconsistently in terms of timing and location	Stocking trauma clinic with sutures and finger tourniquets
Over-processing	Asking patients for the same information several times	Reducing clinical encounters by providing timely treatment, as well as fewer cancellations and delays as patients can be treated in the trauma clinic itself
Inventory	Using inpatient beds for patients to hold a slot on the emergency theatre waiting list	Treatment in trauma clinic meant no inpatient bed required and same-day discharge
Motion	Minimum of 10-minute walking distances between the emergency department, plastic surgery ward, plastic surgery unit and main theatres	Assessment and treatment in the same clinic reducing footfall and the need for transfers; treatment on the day of assessment in clinic, avoiding repeated journeys to and from hospital
Overproduction	Unnecessary dressing clinic or outpatient follow up for minor injuries not requiring specialist input	Follow up in community for minor injuries
Under-usage of staff	Not using all members of staff such as nurses and core surgical trainees for the provision of patient care	Greater inclusion of healthcare professionals at all levels, for example, surgical trainees allocated to the clinic operating list performed the procedures under senior supervision

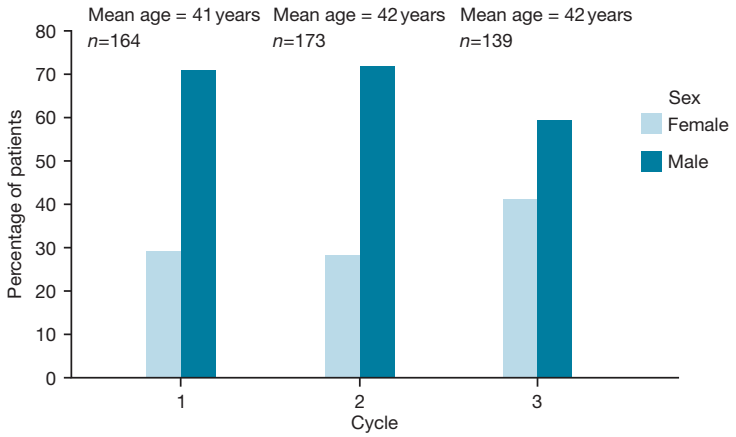

Figure 1. Mean age and sex of patients.

Results

The demographics of patients presenting to the department are displayed in Figure 1. A total of 476 patients were seen in the 6-month period: 164 patients in cycle one, 173 in cycle two and 139 in cycle three. The mean age and age ranges for cycles one to three were 41 years (1–79), 42 years (1–81) and 42 years (1–92) respectively. In cycles one, two and three, 71%, 72% and 59% of patients were male respectively, and 29%, 28% and 41% were female. Figure 2 displays the new care pathways established by the intervention, including treatment decisions and location of treatment for each cycle. After the local anaesthetic trauma list was set up alongside the clinic, all nailbed and extensor tendon repairs were then performed on this list for adult patients. Where nailbed repairs were necessary for paediatric patients, these were still performed in main operating theatres because of the requirement for general anaesthetic. The predominant mechanism of injury was a laceration, followed by crush (Table 2). The location of treatment of the various injury types is shown in Figures 3a–c for each cycle.

The average time taken from referral to being seen in clinic was 1.9, 1.4 and 1.6 days for cycles one, two and three, and did not vary significantly between cycles (P=0.075). However, there was a significant increase in the proportion of procedures performed in clinic after the first 2-month period, when the local anaesthetic operating list commenced (P<0.0001, Figure 4). This was associated with an 11% increase in the proportion of patients treated on the same day of presentation to hospital, ie day 0 ($\chi^2 = 2.05$, P=0.15 (Figure 5).

Discussion

The British Society for Surgery of the Hand (2018a) Working Party report recognised that hand surgery services can vary significantly across the UK. This variability, in addition to the pressure of reduced tariffs paid for hand surgery in the NHS, has created the need for improvements in the organisation and timing of hand injury treatments.

The British Society for Surgery of the Hand recommends that hand surgery units should have dedicated hand trauma theatre sessions and clinics to facilitate timely treatment, and that many cases should be treated as day-cases under regional anaesthesia (British Society for Surgery of the Hand, 2018b). The HandsFirst QI collaborative, currently running across 25 centres in the UK, aims to improve concordance of hand trauma standards with those outlined by the British Society for Surgery of the Hand (Royal College of Surgeons of England, 2021). The hand trauma standards stipulate that 80% of hand injuries requiring surgery should be operated on within 24 hours for open fractures and joints, 4 days for other open injuries and 7 days for closed fractures (British Society for Surgery of the Hand, 2018a).

Figure 2 demonstrates how the care pathway for hand trauma patients was altered by the creation of the local anaesthetic operating list. The implementation of lean models to change treatment processes usually involves creating separate ‘patient streams’ and reorganising staff and physical spaces (Holden, 2011). This approach is often seen in emergency departments, and can be considered analogous to the current intervention, which created two parallel streams of patient care made possible by the redistribution of

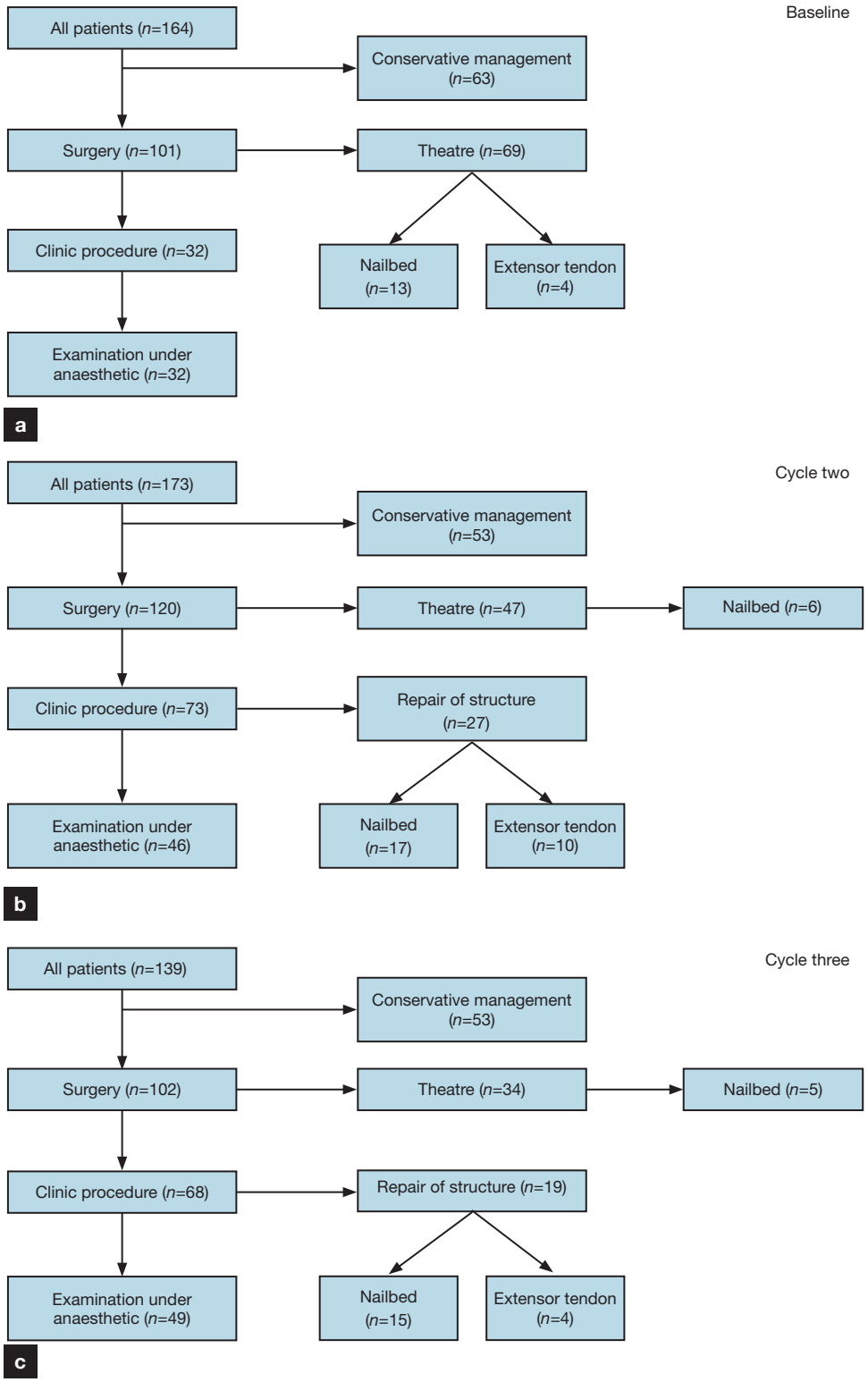

Figure 2. Patient care pathways over 2-month periods, showing (a) baseline activity (cycle one), and following changes implemented in (b) cycle two and (c) three.

staff and equipment within the hospital. While the trauma clinic previously existed only as a location for assessment and triaging patients, introducing the possibility of definitive treatment in clinic created a stream for intervention alongside main theatres.

As a result of implementing the lean thinking model, the clinic reduced delays in trauma treatment (Figure 5) and reduced the requirement for using main theatre operating lists (Figures 3 and 4). Reducing the burden on main theatres addresses different types of

waste (Table 1). This includes reducing the financial impact and resource consumption associated with hand trauma care, which is higher for an operating theatre than clinic. As well as reducing financial or material consumption, treating patients in clinic saves time by addressing waiting, transport, motion and over-processing (Table 1).

Table 2. Types of presenting injuries across all cycles

Injury	% of presentations
Laceration	50
Crush	20
Other	17
Bite	8
Foreign body	5

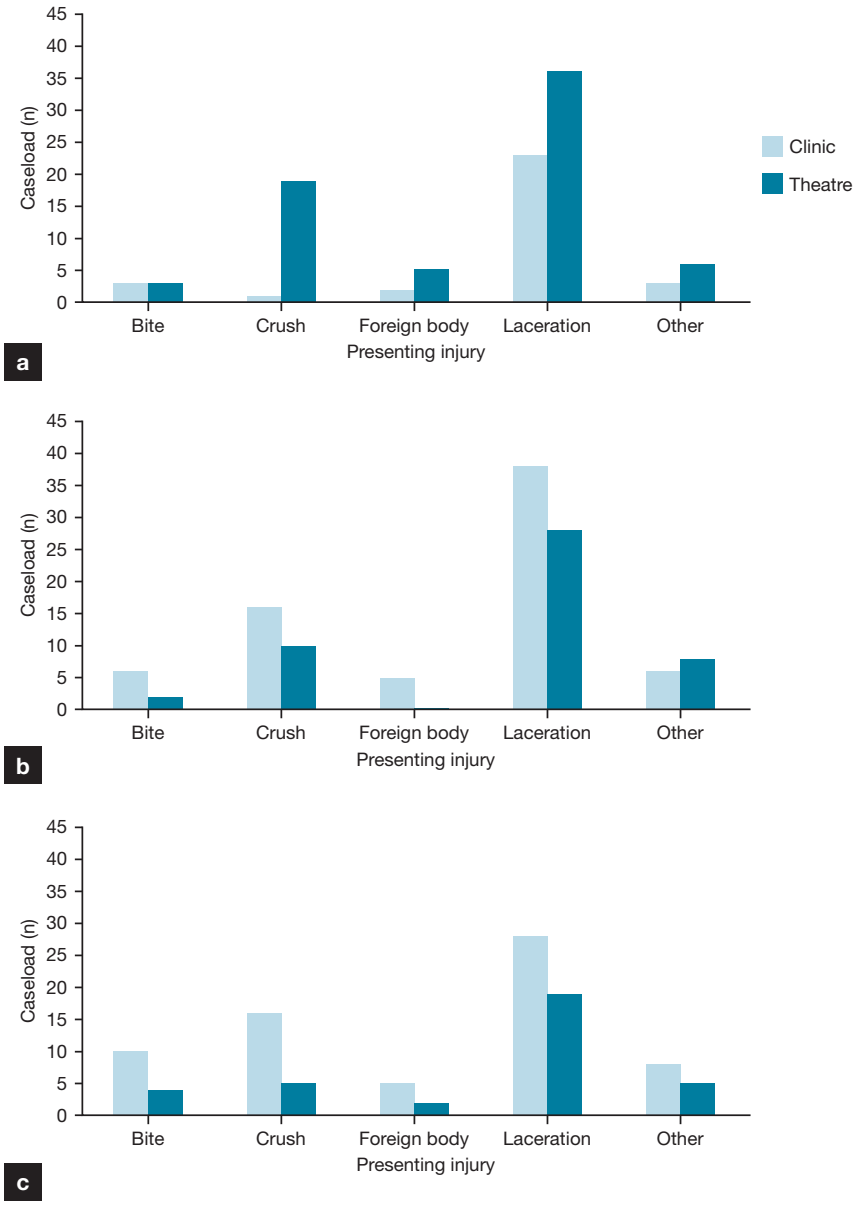

Figure 3. The location of treatment for each type of presenting injury at (a) baseline (cycle one), during (b) cycle two and (c) three.

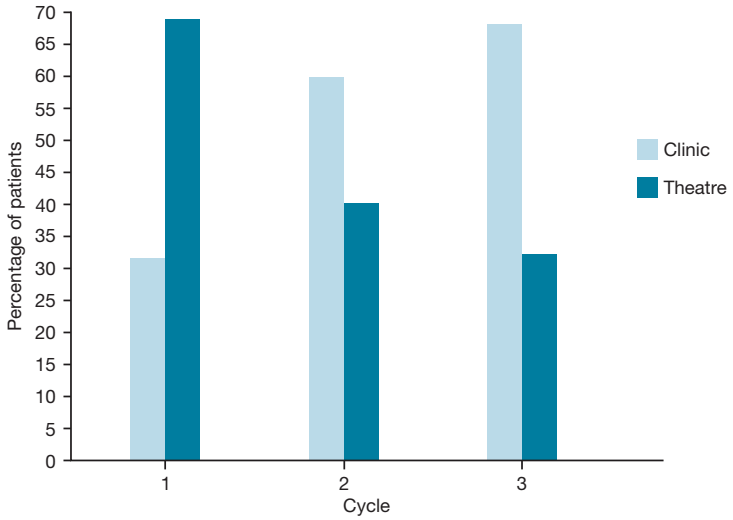

Figure 4. Location of definitive treatment for each cycle.

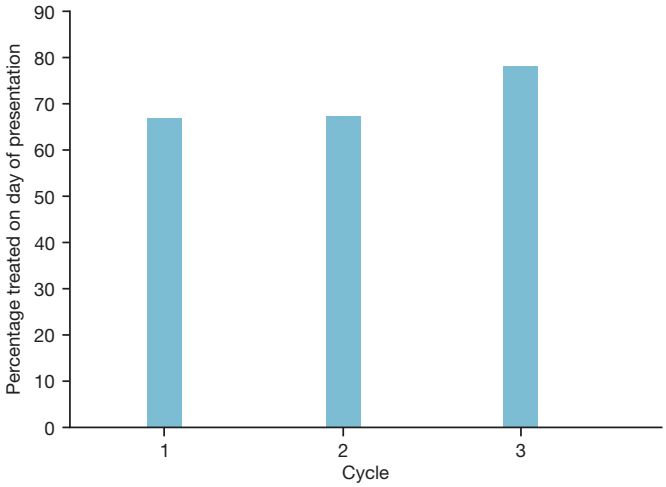

Figure 5. Proportion of patients treated on the day of presentation for each cycle.

Further improvements may have been made by streamlining the referral process, which showed some improvement but did not differ significantly between the three cycles. Given that referrals to this team are made by GPs or staff in the emergency department, implementation of lean principles in this area would necessitate even broader multidisciplinary input. The particular benefit of this would be to reduce patients' waiting times before being assessed (Table 1).

To address the areas of waste, the authors created a care pathway to perform local anaesthetic procedures alongside the trauma clinic. In order to effectively implement this care pathway, the lack of equipment and the need for supervision of trainees needed to be addressed. To meet the need for supervision, a consultant was required to oversee trainees performing procedures in clinic, such as nail bed repair, wound washouts and repair of extensor tendons. To stock the clinic, the required equipment was obtained from the procurement office and main theatres. The implementation of this initiative increased the awareness of the department to the significant flow of trauma patients requiring treatment and need for operating space. Therefore, one elective theatre session was also reserved for trauma cases each week after cycle one.

The lean model aims to eliminate waste for the purpose of increasing efficiency. Another approach, the lean Six Sigma quality improvement model, aims to create consistent processes, through the application of data and statistical analyses regarding past performances. By applying this model, the organisation eliminates defects in its performance (Bevan et al, 2017). Achieving consistency can prove challenging in a healthcare service delivered by humans, because of the human tendency to display inconsistent behaviours compared to automated processes (Bandyopadhyay and Coppens, 2015). In the healthcare setting, the

Key points

- Numerous quality improvement models exist for improving patient care.
- The authors have demonstrated a practical method for implementing the lean quality improvement model in the context of plastic surgery hand trauma care.
- Introducing parallel 'streams' of patient care represents a sustainable method of reducing resource consumption and delays in treatment.
- By applying this model, targets set out by the British Society for Surgery of the Hand become more achievable.

Six Sigma model can be used to reduce medical errors, maintain patient and provider satisfaction through the development of a sustainable patient-care model (Linderman et al, 2003; Arnheiter and Maleyeff, 2005; Toussaint and Berry, 2013). Rapid cycle change is another popular quality improvement model. The model is based on the plan-do-study-act (PDSA) cycle, which facilitates decision-making about small-scale service changes based on measurable improvement (Taylor and Crowe, 1999). A feature common to all of these quality improvement models is a standardised forum for communication.

Importantly, a balance must be achieved between efforts to raise productivity and maintaining patient safety and satisfaction (Farjah, 2016). Greater emphasis on outpatient hand surgery and earlier discharge has been shown to reduce hospital stays and waiting times, without a subsequent decrease in patient satisfaction or safety (Hallet et al, 2019).

The approach implemented in this study poses various difficulties. The lean model requires adequate supervision of trainees, which can become a problem if there are staff shortages. However, over time this provides opportunities for trainees to become competent in performing clinic procedures without supervision, which, in turn, further increases the efficiency of the department. Studies on applications of the lean model do not often comment on the effects on employees as outcomes (Holden, 2011). This study demonstrated positive impacts in this area by providing a supportive training environment for trainees, as reflected in positive feedback received at the usual monthly trainee meetings. This is consistent with the aim of the lean model to maximise staff use and improve their performance (Teich and Faddoul, 2013).

Several studies have demonstrated the efficacy of the lean model for improving the hospital system. Hallet et al (2019) conducted a retrospective study on improving the hand surgery outpatient capacity based on the principles of lean management. Their results revealed that there were significant improvements in length of stay and hospital capacity. Similarly, a study conducted by Tagge et al (2017) revealed that the lean Six Sigma model significantly reduced patient turnover time as well as time between the incision and the application of the surgical dressing.

Conclusions

The successful implementation of small interventions can give rise to significant positive impacts. This study has demonstrated the use of the lean model in effectively improving a plastic surgery trauma service. Through the introduction of the trauma clinic as a location for definitive treatment, waste was reduced by alleviating some of the demand for main operating theatres and allowing early treatment to be provided more consistently. The authors recommend that other trauma centres adopt a similar, dual treatment provision model for the purpose of increasing service efficiency.

Author details

[1]School of Clinical Medicine, University of Cambridge, Cambridge, UK

[2]Department of Orthopaedic Surgery, Monash Health, Clayton, Australia

[3]Department of Plastic and Reconstructive Surgery, Cambridge University Hospitals NHS Foundation Trust, Cambridge, UK

Conflicts of interest
The authors declare that there are no conflicts of interest.

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References

Arnheiter ED, Maleyeff J. The integration of lean management and six sigma. TQM Mag. 2005;17(1):5–18. https://doi.org/10.1108/09544780510573020

Athar MS, Fazal MA, Ashwood N et al. Daycase trauma list: a safe and cost-effective service delivery. Annals. 2019;101(7):519–521. https://doi.org/10.1308/rcsann.2019.0058

Bandyopadhyay JK, Coppens K. Six sigma approach to healthcare quality and productivity management. Int J Qual Productivity. 2015;5(1):1–12

Bevan H, Westwood N, Crowe R, O'Connor M. Lean Six Sigma: some basic concepts. 2017. https://www.england.nhs.uk/improvement-hub/wp-content/uploads/sites/44/2017/11/Lean-Six-Sigma-Some-Basic-Concepts.pdf (accessed 20 May 2023)

Bharsakade RS, Acharya P, Ganapathy L, Tiwari MK. A lean approach to healthcare management using multi criteria decision making. OPSEARCH. 2021;58(3):610–635. https://doi.org/10.1007/s12597-020-00490-5

British Society for Surgery of the Hand. BSSH standards of care in hand trauma. 2018a. https://www.bssh.ac.uk/bssh_standards_of_care_in_hand_trauma_.aspx (accessed 20 May 2023)

British Society for Surgery of the Hand. Hand Surgery in the UK: a resource for those involved in organising, delivering and developing services for patients with conditions of the hand and wrist. Report of a Working Party. 2018b. https://www.bssh.ac.uk/professionals/hand_surgery_in_the_uk.aspx (accessed 20 May 2023)

Farjah F. Improving operating room efficiency–a value proposition. J Thorac Cardiovasc Surg. 2016;151(5):1396–1397. https://doi.org/10.1016/j.jtcvs.2016.01.023

Grunert BK, Matloub HS, Sanger JR, Yousif NJ. Treatment of posttraumatic stress disorder after work related hand trauma. J Hand Surg Am. 1990;15(3):511–515. https://doi.org/10.1016/0363-5023(90)90074-2

Hallet CO, Lois FJ, Nyssen AS, Joris JL. A clinical pathway developed on the principles of lean management improves hospitalisation capacity in outpatient hand surgery: a retrospective study. Eur J Anaesthesiol. 2019;36(7):546–547. https://doi.org/10.1097/EJA.0000000000000973

Hendrickson SA, Phillips GS, Young K et al. Plastic surgical operative workload in major trauma centres (POW-MTC): a UK prospective national cohort study. J Plast Reconstr Aesthet Surg. 2018;71(4):605–607. https://doi.org/10.1016/j.bjps.2017.09.009

Holden R. Lean thinking in emergency departments: a critical review. Ann Emerg Med. 2011;57(3):265–278. https://doi.org/10.1016/j.annemergmed.2010.08.001

Linderman K, Schroeder RG, Zaheer S, Choo AS. Six sigma: a goal-theoretic perspective. J Oper Manage. 2003;21(2):193–203. https://doi.org/10.1016/S0272-6963(02)00087-6

Moran CG, Lecky F, Bouamra O et al. Changing the system - major trauma patients and their outcomes in the NHS (England) 2008–17. EClinicalMedicine. 2018;2–3:13–21. https://doi.org/10.1016/j.eclinm.2018.07.001

National Audit Office. Major trauma care in England. London: The Stationery Office; 2010

Robinson LS, Sarkies M, Brown T, O'Brien L. Direct, indirect and intangible costs of acute hand and wrist injuries: a systematic review. Injury. 2016;47(12):2614–2626. https://doi.org/10.1016/j.injury.2016.09.041

Royal College of Surgeons of England. HandFirst QI collaborative. 2021. https://www.rcseng.ac.uk/standards-and-research/standards-and-guidance/service-standards/handsfirst-qi-collaborative/ (accessed 20 May 2023)

Tagge EP, Thirumoorthi AS, Lenart J, Garberoglio C, Mitchell KW. Improving operating room efficiency in academic children's hospital using Lean Six Sigma methodology. J Pediatr Surg. 2017;52(6):1040–1044. https://doi.org/10.1016/j.jpedsurg.2017.03.035

Taylor JA, Crowe VL. Rapid cycle change sells itself. J Healthc Qual. 1999;21(5):4–7. https://doi.org/10.1111/j.1945-1474.1999.tb00982.x

Teich ST, Faddoul FF. Lean management-the journey from Toyota to healthcare. RMMJ. 2013;4(2):e0007. https://doi.org/10.5041/RMMJ.10107

Toussaint JS, Berry LL. The promise of Lean in health care. Mayo Clin Proc. 2013;88(1):74–82. https://doi.org/10.1016/j.mayocp.2012.07.025